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Education and Innovation:
Key to Sustaining Lake Winnipeg

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In a world where the effects of urbanization have severely affected the environment [1]-[2], Canada shines as a perfect mix between bustling cities and natural landscapes. Natural landscapes, more specifically, are what make Canada one of the most beautiful places in the world. From towering mountains like the Canadian Rockies to picturesque views like the Niagara Falls, Canada is chockful of jaw-dropping sights. One sight, however, is in danger because of human influence, and that is Lake Winnipeg.

Lake Winnipeg, after its emergence from the prehistoric Lake Agassiz [3], has played a significant role in the lives of Canadians. By the start of the 20th century, railways located along Lake Winnipeg connected Winnipeg to Selkirk [4], thus making travel easier for the denizens of both Winnipeg and Selkirk. Furthermore, railways along Lake Winnipeg's south basin made it easier for Winnipeggers to escape city life and retreat to the natural beauty of the lake [5]. Winnipeg Beach became one of the first destinations that Canadians decided to visit after railways were built near Lake Winnipeg in 1903 by Canadian Pacific [5]. Winnipeg Beach and other destinations located along Lake Winnipeg continue to instill unforgettable experiences in the minds of Canadians even to this day. Besides being a hub for activities, Lake Winnipeg is also home to more than 23,000 Canadians, including 11 First Nations communities [6]. These communities, particularly First Nations communities, have fought for preservation of the lake, which cultivated their culture and their lives [7]-[8].

Lake Winnipeg also serves as a source of power since Manitoba Hydro was given a license to regulate the lake in 1970 [9]. Additionally, Lake Winnipeg contributes to the hydroelectricity output of Manitoba, which accounts for almost 98% of overall energy production in Manitoba in tandem with wind power. [10]-[11].

Despite its natural beauty and significance to Canadians, Lake Winnipeg is in danger of the very Canadians who use it. In recent years, algae bloom levels in Lake Winnipeg have increased [12]. This increase in algal blooms is primarily because of the corresponding increase in phosphorus and nitrogen levels in the lake [13], which, in turn, is a result of human activities that produce wastewater, fertilizers, and animal wastes [14]-[15]. In fact, the significant rise in algae blooms in Lake Winnipeg is so severe that the algae blooms can even be seen from outer space [16].

Furthermore, the increase in algae blooms can have harmful consequences to Lake Winnipeg and those living near it. Algal blooms can produce neurotoxins that can be more powerful than cobra venom [16]. Additionally, blue-green algae, also known as cyanobacteria, can generate toxins that contribute to liver and respiratory failure in humans and animals [17]. Blue-green algae, specifically, is observable in Lake Winnipeg [18]-[19]. In regards to the effects of algae blooms to Lake Winnipeg itself, the blooms can affect the chemical composition of the lake [20]. When algae blooms die, they sink to the bottom and undergo decomposition, a process that can take in oxygen [21]. Lower oxygen levels could then result in an insufficient amount of oxygen available for aquatic life inhabiting the lake [16], [20].

It is clear that the increase in phosphorus and nitrogen levels in Lake Winnipeg have negative implications on the lake itself and on the organisms that utilize it. A question then pops up in regards to these problems: how can Canadians sustain and revitalize Lake Winnipeg?

Before going on to solutions to Lake Winnipeg's algae problem, it is important to note that the Red River Basin contributes almost 60% of the phosphorus loads in Lake Winnipeg [22]. Since the Red River Basin contributes more than half of the phosphorus in Lake Winnipeg, treatment efforts should be more focused on the basin. It is also important to note that allegations suggesting that Lake Winnipeg is dying are false. The suggestion that Lake Winnipeg is not dying is observable in findings stating that the south basin of the lake had no hypoxic events within any year besides one station [19]. This suggestion is also observable in the shallow depth of the lake, which inhibits stratification, a pre-condition for hypoxia and anoxia [19]. Nevertheless, it is still important to solve Lake Winnipeg's algae problem so that allegations suggesting that the lake is dying would not come true.

One possible solution to Lake Winnipeg's phosphorus and nitrogen levels is the production of nano-enhanced media. In fact, a research project conducted by Steven Safferman, a professor from Michigan State University, and MetaMateria Technologies showed that nano-media, specifically those made with waste iron, can efficiently absorb phosphorus from water [23]. Additionally, nano-media showed no major changes in performance throughout different facilities [23], indicating nano-media's flexibility in different experimental sites. Additionally, phosphorus removal rates during the research project were not affected by compounds that might populate different industrial and municipal sources of wastewater [23]. The lack of change in phosphorus removal in industrial and municipal sources, in tandem with the lack of change in the nano-media's performance throughout various facilities, could prove to be advantageous in Lake Winnipeg. Furthermore, since nano-media is considered cost-effective and reusable [23], it could be utilized for long periods of time and its manageability would be easier.

Another solution to Lake Winnipeg's increasing phosphorus and nitrogen levels is the utilization of aquatic macrophytes, specifically *Pistia* and *Eichhornia crassipes.* The use of *Pistia* and *Eichhornia crassipes* to filter out harmful material from Lake Winnipeg can conveniently be called phytoremediation [24]. *Pistia,* which can be called water lettuce [25], is an efficient nutrient remover due to its rapid growth and high biomass potential [26]. What is even more encouraging is that the nutrient removal potential of *Pistia* increases as the nutrient concentration of an area increases. Since Lake Winnipeg has high concentrations of phosphorus and nitrogen [13], it can be inferred that *Pistia* has promising potential in Lake Winnipeg. The same potential can be said for *Eichhornia crassipes*, which has a higher nutrient removal-capacity than that of *Pistia* [27].

More general solutions to Lake Winnipeg's problems include increasing public awareness about Lake Winnipeg and urging the public to lessen activities that promote the increase of phosphorus and nitrogen. The government of Manitoba could invest in public education programs and public announcements that would increase the awareness of the general populace about the dangerous levels of phosphorus and nitrogen levels in Lake Winnipeg. Additionally, these public awareness programs can introduce ways to help alleviate Lake Winnipeg's problems. Activities such as reducing animal waste runoff and decreasing the use of phosphate-containing detergents can be promoted by the public awareness campaign. This kind of program would then need the collaboration of both local media outlets and government officials for the proposal to be beneficial for Lake Winnipeg. The local media can circulate newspapers, brochures, signs, and infomercials at a regular basis to ensure that the preservation of Lake Winnipeg will remain in the minds of the locals.

Furthermore, there are cases in which increasing public awareness has been beneficial for areas of concern. A prime example of successful public awareness programs is the Albury-Wodonga campaign in 1993 that aimed to reduce phosphorus emissions to the Murray-Darling

river system [28]. The campaign, organized by the Albury City Council, initiated a community awareness program that received partnerships from neigbouring councils and the Federal Government [28]. The Albury-Wodonga campaign utilized weekly television advertising, newspaper advertising, annual mail letters, and educational programs [28]. In-depth surveys were also conducted to analyze the public's knowledge of water pollution [28]. By the end of the campaign, phosphorus levels were reduced by 18% with an average of about 112 kg/d compared to the benchmark figure which was 142 kg/d [28]. Interestingly, the decrease in phosphorus load withstood an increase in population and industry growth during the campaign period [28]. It can be concluded that a comprehensive public education campaign aiming to increase awareness results in a successful decrease of the problems and that targeting the problem at its source can provide long-term benefits to the area of concern.

To successfully decrease algae bloom and maintain low algae bloom population in Lake Winnipeg, the combination of on-site and off-site solutions is desirable. On-site solutions like nano-media and aquatic macrophytes show potential and can be implemented into the Red River Basin to decrease a substantial portion of the phosphorus load in the basin. Meanwhile, off-site solutions like the implementation of a public awareness campaign can provide long-term solutions by influencing locals into decreasing their phosphorus output in Lake Winnipeg. Hopefully, this will allow the public to continue enjoying the beauty of Lake Winnipeg.

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